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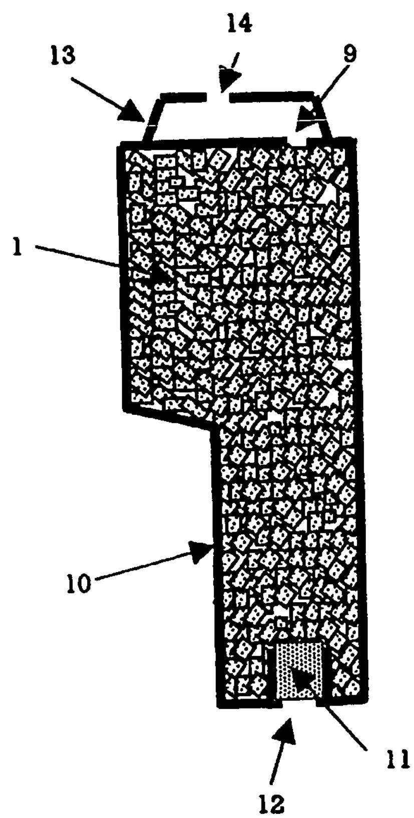
(54) Title: MULTIPLE MEMBERS ACTING SINGULARLY FOR RETAINING FLUID

(57) Abstract

An ink storage media that comprises of a plurality of smaller pieces (1) such that when the smaller pieces (1) are combined, they have no particular shape prior to insertion into a container (10). When they are installed into a container's cavity, the plurality of pieces (1) conform to the inner shape of the cavity, therefore, the cavity does not need to be of any particular shape relative to the storage media. For ink jet cartridge applications where the media stores ink, the plurality of small pieces (1) performs as well as, and often better, than a single piece of media in the same application. The plurality of pieces (1) of the present invention can be made from various materials that have the potential to store fluids such as, but not limited to, foams, felts or fibers.



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MULTIPLE MEMBERS ACTING SINGULARLY FOR RETAINING FLUID

DESCRIPTION

TECHNICAL FIELD

The present invention relates to devices for storing and dispensing fluids. More particularly the present invention relates to storing and dispensing ink for a print head using thermal ink jet, piezo ink jet or continuous ink jet printing technologies.

BACKGROUND OF INVENTION

Printers for small office or home use have realized significant advances in printing technology in recent years. Ink jet printing, also known as drop on demand printing, has become more affordable and faster. The cartridge's ink storage mechanisms have somewhat improved, but the bulk of the ink storage media is still a single piece of foam that has been shaped and stuffed into a cubic cartridge who's shape potential is limited by the economy of foam cutting technology.

An ink cartridge has to remain leak free during normal environmental changes. Atmospheric pressure and temperature changes can increase or

decrease the air pressure inside the cartridge relative to atmosphere. The pressure differential can cause ink to leak out of the cartridge, which is unacceptable for the user. Many mechanisms have been patented to handle leakage and environmental changes such as Hewlett Packard's patent or my invention, assigned to Xerox, The Document Company, patent. Hewlett Packard's cartridge, 51626A, utilizes the mechanism described in their patent. This mechanism is very efficient for compensating environmental changes, but is more expensive than foam.

Simpler cartridges store the ink in a media, typically a piece of foam or felt, see Hewlett Packard's patent 4,771,295, my invention assigned to The Document Company, patent 5,420,625 or Kodak's patent 4,929,969. The storage media described in these patents provide ink-holding capability due to ink and media capillary forces. The foam must be specifically tuned to the ink and cartridge so that the forces are high enough to hold the ink but low enough to release the ink for printing. The media filled container has a strategically placed hole that equalizes the internal pressure with that of the atmosphere, coupled with the ink stored in the media, the cartridge remains leak free during normal shipping and handling.

The foam piece can be cut from a variety of base foam formulations such as polyurethane-ether, polyurethane-ester, melamine, etc. Foam can also be manufactured to be hydrophobic or hydrophilic. The foam piece is cut from a larger piece called a bun. The foam's raw chemicals are ejected from a mixing head into a large receptacle that is several feet wide two feet high, who's length is moveable so that the bun can be made to a varying length. During the foaming process, a skin forms on the outside of the bun rendering that portion unusable for ink jet applications. There are variations in the foam density throughout the bun resulting in porosity variations.

Foam is then cut to manageable pieces for further processing. The foam can be felted, which is process that compresses and heats the foam, which permanently reduces its size in the direction of the compression. Felting

elongates the cell structure. A foam that has been compressed to 1/3 of its original size is described as being felted 3:1.

Often foams have cell walls or partial walls that are undesirable for ink storage and release. The cell walls can be removed through a process called reticulation. The reticulation process does not remove all of the walls. Some foam is processed that do not have these walls and are called innately reticulate.

A cartridge manufacturer desires a foam that has uniform physical properties, such as size, base material formula, cell structure, etc. Foam inconsistencies can cause performance variations from cartridge to cartridge. The felting process produces variations in the foam. The elongated cell structure resulting from the felting process varies through the foam in the direction of the felt becoming less dense in the center of the foam. The variations become more pronounced as the felted piece of foam increases in the felting direction. This is an undesirable effect and can interfere with desired cartridge operation.

In most cases for ink retention uses, when the felted foam is cut to its final shape, the direction of felting must be oriented relative to the cutting tool. This is because ink can behave differently as it moves through vertically oriented elongated cells vs. horizontally oriented elongated cells.

Foam is very flexible and is difficult to cut to a single precise shape and size. Cutting is two dimensional in nature where a foam's length and width can vary in shape but the thickness is one dimension. Making a single foam shape that varies in three dimensions, increases tooling and piece part costs. Tight tolerances are required for the foam's dimensions else insertion and functionality problems can occur. The cartridge shape is primarily driven by the economy of foam shaping. Rectangular shaped cartridges allows for the least expensive foam piece. Cartridges that require other shapes, such as an "L" shaped piece of foam cost more to make and install and are thereby avoided if possible.

Several methods are used to cut the foam, including water jet cutting, rotary die cutting, linear die cutting, saw cutting, hot wire cutting, knife cutting and shearing. Often more than one of these methods is used to create a single piece of foam.

The cartridge drives the printer's architecture. The limitations of foam cutting with the economy of cutting complex shapes, force designers to use what is affordable often increasing the printer's length and width as a tradeoff to cost.

Foam is designed to hold ink and deliver ink to the print head. The print head has an operating pressure (backpressure) requirement. If the foam is too absorbent (in other words has a high backpressure), the print head will not print as desired. If the backpressure is too low, ink will drip from the print head and the cartridge will not be portable if separated from the printer.

Inks for varied uses have different ink properties such as viscosity, specific gravity, surface tension, etc. Some of the foam's properties can be optimized, but are limited to felting ratio, base formula and porosity.

The cartridge manufacturer may have several products that use different foam based cartridges. Each product may use different ink and the manufacturer likely uses several different foam compounds and / or base foam formulations with differing felting ratios for each application. Each product usually requires a different foam shape.

A single piece of foam, by definition, can only be made from one base material formulation, for example polyurethane – ether. A cartridge designer desires that the foam have specific properties relative to the cartridge's function. The cartridge designer can vary parameters of a single foam formulation to achieve acceptable ink retention and release performance. With limitations, he can vary the raw material's porosity. This is done during foam production and is specific to the foaming process. The cartridge designer can vary the porosity as high as 90 pores or cells per inch.

Once the foam has cured it can be further processed by felting (not to be confused with the material felt), a process that compresses the material under heat, which permanently changes its thickness. Felting is typically described in terms of ratio where the ratio is the original thickness divided by the final thickness. Foam that has been compressed to one inch from an original thickness of three inches has a felting ratio of 3:1. Felting foam can fine-tune a cartridge system achieving acceptable ink holding and retention properties. Another way

to achieve similar results is to stuff an oversized, non-felted piece of foam into the cartridge cavity called over-stuffing. The felted foam is more expensive than non-felted foam, however the manufacturing costs of over-stuffing can be higher. An example of a felted foam piece whose shape matches the cartridge's cavity size is the Canon BCI-21 black cartridge. An example of foam that is overstuffed is Lexmark's 4076 black cartridge.

A single piece of foam can be made to be either hydrophobic or hydrophilic. Depending upon the ink and cartridge, either may be used but primarily hydrophobic is seen in the majority of the art. This is because hydrophilic foams tend to have a backpressure that is too high to achieve acceptable cartridge performance. During the cartridge assembly process, ink is forced into the hydrophobic foam. After the hydrophobic foam is filled with ink, the foam becomes wetted. Once ink is removed from the foam, the foam acts hydrophilic because the foam has residual ink remaining on the strands of foam. A cartridge that has a target to hold 10 ccs of ink can therefore be filled with 11 ccs during the manufacturing process and then one cc can be removed as a final step to the filling process. Removing one cc of ink in this case creates wetted foam cells above the bulk of the fill providing the forces necessary to keep the ink from dripping out of the container.

Felt materials are also used in ink jet cartridges to store and release ink. My co-invention, US5420625: Ink supply system for a thermal ink-jet printer, uses needled polyester fibers that are cut to a shape prior to insertion into the cartridge. This invention has been put into practice with Xerox's black ink jet cartridge, part number 8R7638. The thickness of the pre-cut material is limited by the needling process where only about 3/8" pieces of the desired density can be made, causing Xerox's cartridge design to layer three shaped pieces to achieve the ink storage desired.

Accordingly, there is a need to relieve the cartridge and printer manufacturer of the difficulties associated with implementing ink storage media into the design.

BRIEF SUMMARY OF THE INVENTION

The present invention meets the needs in the art by relieving many cartridge design difficulties resulting from implementing foam into an ink cartridge. The present invention replaces the current art's single piece of shaped foam, with a plurality of small pieces of foam that start out as a shapeless mass conforming to the shape of the cartridge when installed into the cartridge.

Using this invention, offers the cartridge developer many advantages over a single shaped piece of foam including; cost advantages, shorter cartridge design cycle, lighter cartridge weights, increased system efficiency, fewer parts to inventory and specify, elimination of single piece insertion problems and real time foam density adjustment during the development cycle. The cartridge developer can further design the ink cartridge to virtually any shape if the present invention is used, including very small cartridges where foam cutting would be costly and very difficult. Cartridge shapes that have a small opening, but a large storage area, such as a bottle with a small neck, can easily be filled with the present invention, where a single piece in the same situation would not be practical and likely would not effective fill the bottle. When foam is described throughout the discussions of this disclosure, shapeless felt fibers or felt pieces could also be used instead of foam pieces.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a cross section of Canon BCI-21, black ink jet cartridge whose foam has been replaced with the present invention of a plurality of foam pieces. Figure 2 shows a different foam based cartridge similar to Canon's BJ-600 family ink jet cartridges who's single piece of foam has been replaced with the present invention of a plurality of foam pieces. Figure 3 shows a blend of the present invention where 70% of the mix is melamine based foam and is blended with 30% polyurethane-ether foam, 70 pores per inch that has been reticulated and felted 3:1 prior to cutting in pieces.

DETAILED DISCRIPTION OF THE INVENTION

The present invention offers the cartridge designer more system parameter adjustment, achieving the desired cartridge system results. The nature of the invention is a shapeless collective of small pieces of foam where a combined shapeless mass of the pieces fills and conforms to the inner shape of the ink cartridge. The foam pieces in mass function together as an ink retention / release system. The mass's foam pieces can all be from the same type of foam with its associated properties such as polyurethane–ether, 70 pores per inch and felted 3:1. The mass can also be formulated out of two or more mixed foam materials such as 25% polyurethane –ether - hydrophobic, 70 pores per inch and felted 3:1, 50 % melamine and 25% as polyurethane –ester - hydrophilic, 70 pores per inch and felted 1.5:1. Mixing foam materials has potential properties that current art, a singular piece, can not realize. The ink cartridge can also be layered with various formulas of the present invention where one material and covered with additional layers of other materials to optimize the cartridge's operating efficiency. The current invention's composite mixing capability offers exponential possibilities relative to a single foam piece resulting in enhanced system control.

One can further imagine that a formula mix of foam pieces, having different properties as previously outlined, can be permanently contained in a mass using a binder or a bonding agent. This would yield a solid mass of foam similar to the present art of a single piece, but with much more potential to blend enhanced physical parameters within the piece. The mass can then be shaped to fit the cartridge using current foam shaping techniques.

Often the foam piece has to be cleaned because free residual compounds remain from the foaming process, which changes the ink properties, interfering with print quality. Cleaning can also remove stray cell walls that reticulation has left behind. Often a water and solvent solution is used to clean the foam. The foam is then dried. The small foam pieces of the present invention make cleaning easier because there are no deep cells that the cleaning has to penetrate. Drying is also faster because there are no deep wetted cells to dry. Often the innermost

cells in the best embodiment of the present invention are only 3 or 4 cells from their surface of the individual piece.

A singular piece of standard foam, such as melamine for example, has thousands of cells that are created by the network of connected strands of the base foam material. The ink is stored in these cells and migrates along the strands from cell to cell as ink is removed from the foam. The capillary attraction of the ink to the strands and cells creates the desired backpressure. The ink that is stored and released in the current invention is different than the single piece of foam because the ink is stored in both the cells created by the strands and the thousands of interfaces between the pieces of foam. The ink also flows through the mass of foam pieces both through the cells created by the strands and the interfaces between the pieces of foam. When different foams are combined into one mass the storage and movement of the ink is further varied due to the varied properties of the individual foam pieces.

Melamine foam is low in density and works well for holding and releasing ink. Cartridge manufacturers do not like to use melamine foam or foams that have porosity variations (those that have a large distribution of cell sizes) because of the holding and releasing inconsistencies caused by these variations. When the melamine is processed into small cubes, the voids are negated. The voids are larger that the present invention's pieces. Where there is a void relative to the cutting tool, a cube will simply not be created. Therefore, melamine foam porosity variations can be negated when the foam is sectioned into small enough pieces such as the present invention.

Some cartridges that are removed from the print head have openings exposing the foam piece. One such example is the Canon BJC-600 cartridge. When this cartridge is installed, the foam piece engages with the print head's collection port allowing ink to flow from the cartridge to the print head. If the cartridge's single piece of foam were replaced with the small pieces of the present invention, the foam pieces would normally fall out of the opening. However, after the small pieces are in place, a piece of filter cloth or a disk of thin foam that is slightly larger than the opening can be inserted into the opening

which allows ink to pass through while the foam pieces hold the disk in the desired position. The vent hole of this cartridge is small enough where the foam pieces will not fall out

Drawing 1 shows a cross section of a typical cartridge design 8 used by Xerox and Canon, who's single piece of foam (not shown) has been replaced with the present invention's plurality of foam 1. A barrier 4 is placed into the opening 3 that allows fluid to transfer through the barrier. The barrier 4 can be a filter, cloth or disk of foam. The adjacent section 7 opposing the foam stores free ink 6. As the ink (not shown) in the foam section 1 is drawn through opening 3, the level of ink in the foam is depleted and air enters port 2 which equalizes atmospheric pressure and the pressure inside the foam filled half. As the ink is further depleted, an air pathway becomes available, through the foam, to opening 5. As the ink is further drawn out of the ink section 6, the pressure drops in the air above the ink drawing air from the aforementioned air pathway through opening 5 which creates bubbles in the ink until the bubbles reach the area above the ink 6, temporarily equalizing the pressure with atmosphere until more printing occurs.

Drawing 2 shows a cross section of a typical ink jet cartridge, the Canon BCI-21 black cartridge 10, who's single piece of foam (not shown) has been replaced with the present invention's plurality of foam 1. In the case of the Canon BCI-21, if the plurality of foam were not present, the cartridge 10 would have an internal volume of 16ccs. The plurality of foam 1 can be a mass of melamine foam cubes that has been cut to 3/32" per side. The predetermined amount of cubes 1 is stuffed into the cartridge such that they entirely fill the desired space within. The amount of foam that is stuffed into the cartridge 10 can have an effective density of 0.50 lb. per cubic foot, which is less than the standard melamine bulk foam density of around 0.75 lb. per cubic foot or less. This accomplished by adding relatively fewer cubes to the container. The effective density of the melamine cubes 1 can be 1.0 lb. per cubic foot or more by adding more cubes to the container. The same density effect can be achieved with other base foam formulations.

Drawing 2 further shows that a wick 11 is present in the bottom of the cartridge at opening 12 where the ink (not shown) stored in the plurality of foam 1, is drawn from the print head (not shown). The vent 14 and the vent opening 9 allow the air inside the cartridge to equalize with atmospheric pressure as the ink is depleted from the cartridge. The space created between the top 13 and the wall 15 helps to keep stray ink from leaking outside the cartridge.

Drawing 3 shows one example of the virtually infinite number of composite cube mixes that are possible. Regardless of the mix, the many combinations start out shapeless and conform to the shape of the cartridge's internal cavity. The foam percentages shown can be varied. A third, fourth, nth, foam can be added. The cubes can also be different sizes. The mix can contain foams that are felted 1.5: 1, foams that are 2:1, n:1. The mix can contain foams that are unfelted, reticulated, non-reticulated, innately reticulate, hydrophobic, and / or hydrophilic. The mix can contain fibers, cloth pieces or felt pieces. The ink storage cavity can be stuffed to a density less than the pre-cut foam material or can be stuffed to a density that is more than the pre-cut foam material.

The principals, preferred embodiments, and modes of operation of the present invention have been described and outlined in the foregoing application. This invention is not to be construed as being limited to the particular forms disclosed because the disclosure illustrates the invention and does not restrict it. Those skilled in the art may make changes without departing from the spirit of the present invention that is described in the following claims.

MULTIPLE MEMBERS ACTING SINGULARLY FOR RETAINING FLUID

CLAIMS

I Claim:

1. A container that is at least partially filled with a liquid with the intent of utilizing said liquid and said container is at least partially filled with a mass: whose said mass comprises of a plurality of pieces that are smaller than the collective mass;

   where said liquid is at least partially stored in the mass;

   where said smaller pieces are mutually in contact with each other, either directly or indirectly via adjacent pieces; and

   whose said mass has no particular shape prior to inserting into said container.
2. The device described in claim 1 whose mass is a plurality of foam pieces.
3. The device described in claim 1 whose mass is a plurality of felt pieces.
4. The device described in claim 1 whose mass is a plurality of felt fibers.
5. The device described in claim 1 whose said container has at least one dedicated opening allowing communication between the atmospheric pressure and the volume inside the container and at least one dedicated opening with potential to transfer fluid out of said container.
6. The device described in claim 1 who's said liquid is ink.
7. The device described in claim 1 where at least one partial mass differs in at least one physical property from the remaining mass.
8. The device described in claim 1 whose described mass is a plurality of foam cubes.
9. The device described in claim 1 whose described mass is a plurality of foam pieces that have been frozen and then crushed from a larger piece.
10. The device described in claim 1 whose described mass is a plurality of shredded pieces of foam.

11. The device described in claim 2 whose plurality of foam pieces has an effective density that is less than the foam prior to processing into the individual pieces.

12. The device described in claim 2 where the plurality of foam pieces has an effective density that is greater than the foam prior to processing into the individual pieces.

13. The device described in claim 2 where said foam is made from polyurethane foam.

14. The device described in claim 2 whose said foam is not reticulated.

15. The device described in claim 2 whose said foam is innately reticulate foam.

16. The device described in claim 2 whose said foam is not reticulated.

17. The device described in claim 2 whose said foam is made from a thermoset melamine condensate.

18. The device described in claim 2 where the said foam pieces are felted.

19. An ink cartridge that contains foam such that prior to installing the foam into the cartridge, the foam is not strategically shaped to match the inner shape of the cartridge.

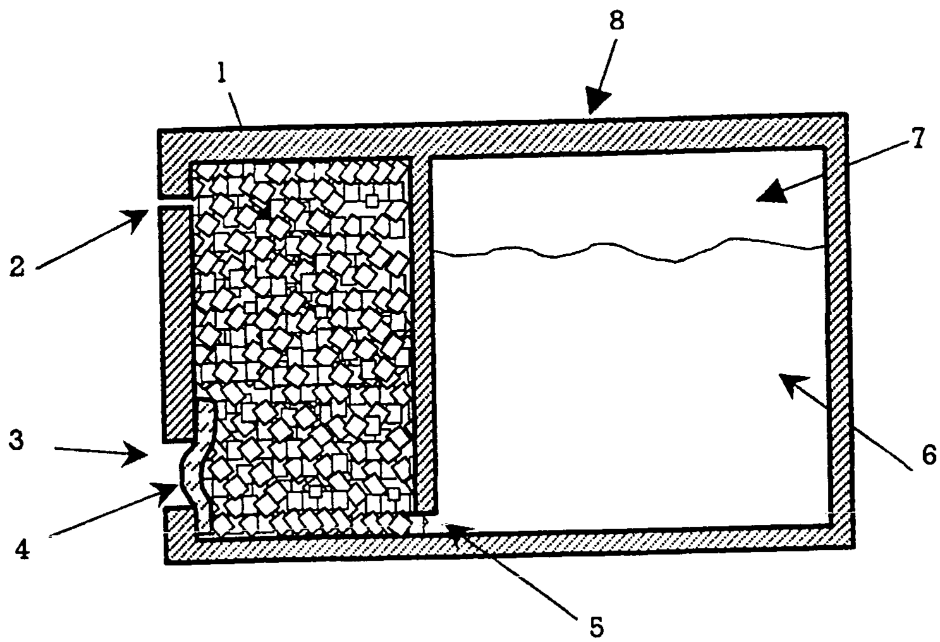
20. A liquid storage container:

containing a fluid holding media: and

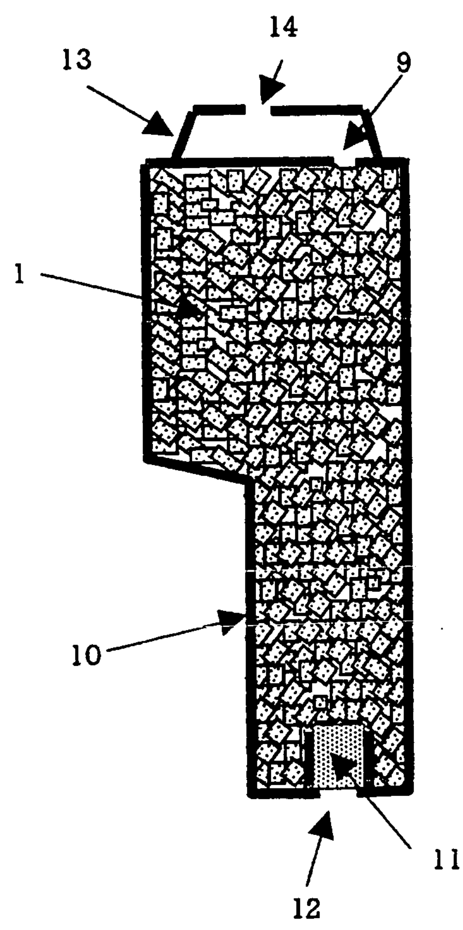
whose shape does not derive from the shape of the media that is used to store the liquid.

MULTIPLE MEMBERS ACTING SINGULARLY FOR RETAINING FLUID
DRAWINGS

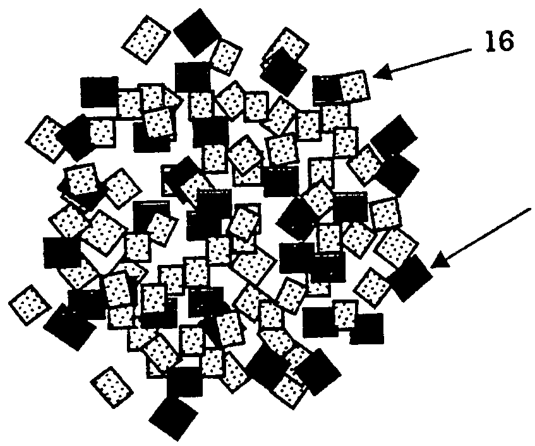
DRAWING 1



Drawing 2



DRAWING 3



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- COMPOUND 1, FOR EXAMPLE: 70 % Melamine 0.75 lbs / cubic foot (ITEM 16)

- COMPOUND 2, FOR EXAMPLE: 30% Polyurethane-ether, reticulated, cut from foam and felted 3:1, 70 pores per inch (ITEM 17)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/16737

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : B41J 2/175
US CL : 347/85-87
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 347/85-87

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y, P	US 5,815,184 A (UJITA et al) 29 September 1998 (29.09.98), Figures 6-11. .	1, 2, 5-12, 19, 20 ------ 3, 4, 13-18
Y	US 5,856,838 A (ODA et al) 05 January 1999 (05.01.99), col. 10, first paragraph.	3, 4, 13, 18
Y	US 4,929,969 A (MORRIS) 29 May 1990 (29.05.90), col. 5, lines 59+.	14-17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search

28 AUGUST 1999

Date of mailing of the international search report

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